

REMARKS

In response to the Final Office Action dated March 2, 2011, and the Pre-Brief Appeal Conference Decision of August 2, 2011, and further to the Applicants' response of August 30, 2011, Applicants respectfully request reconsideration based on the above claim amendments and the following remarks.

Claims 1-5 and 7-10 are pending in the present Application. Claim 10 has been amended, and claim 6 cancelled, leaving claims 1-5 and 7-10 for consideration upon entry of the present amendment.

Claim 1 has been amended for proper antecedent basis, supported at least in the specification as originally filed on p. 4, line 29.

Support for the amendment to claim 10 can be found at least in the specification as originally filed on p. 4, line 29.

Reconsideration and allowance of the claims are respectfully requested in view of the above amendments and the following remarks.

Examiner Interview

The Applicants thank the Examiner for the courtesy extended in the interview of September 13, 2011. In the interview the Examiner stated that claim 1, as amended, was novel and non-obvious over the cited art. Also, the Examiner stated that if claim 10 were to be amended to include the limitation, "wherein a thickness of the inorganic electron transport layer is in a range of about 10 nanometers to about 100 nanometers," then claim 10 would also be novel and non-obvious over the cited art.

Claim Rejections Under 35 U.S.C. § 103

For an obviousness rejection to be proper, the Examiner is expected to meet the burden of establishing why the differences between the prior art and that claimed would have been obvious. (MPEP 2141(III)) "A patent composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art." *KSR Int'l Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 1741 (2007). To find obviousness, the Examiner must "identify a reason that would have prompted a person of ordinary skill in the art in the

relevant field to combine the elements in the way the claimed new invention does.” *Id.* Also, to establish *prima facie* obviousness of a claimed invention, the prior art references must teach or suggest all of the claim limitations. (MPEP 2143(A)(1))

Claims 1, 2, 4, 5, 8 and 9 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Bulovic et al. (U.S. Patent Publication No. 2004/0023010, hereinafter “Bulovic”) in view of Jain et al. (U.S. Patent no. 6,797,412, hereinafter “Jain”) and further in view of Chen et al. (U.S. Patent Publication No. 2002/0251824, hereinafter “Chen”).

Claims 3 and 7 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Bulovic in view of Jain and Chen, and further in view of Kishigami (Japanese Patent No. 200-215984, hereinafter “Kishigami”).

Claim 10 stands rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Bulovic in view of Kishigami and further in view of Chen.

In making the rejection of independent claim 1, the Examiner states that Bulovic does not disclose that the electron transport layer (“ETL”) is inorganic and that the substrate is polyethyleneterephthalate (“PET”) or polycarbonate (“PC”), states that Jain is silent as to PET or PC, alleges that Chen teaches a device wherein the substrate is made of PC, and states that it would have been obvious to use the inorganic ETL of Jain in the device of Bulovic and to further modify with the PC substrate of Chen. Final Office action of March 2, 2011, pp. 3-4. Similarly, regarding independent claim 10, the Examiner alleges that Bulovic does not disclose that the ETL is inorganic, states that Kishigami is silent as to PET or PC, states that Chen teaches a device wherein the substrate is made of PC, and states that it would have been obvious to replace the ETL of Bulovic with the inorganic ETL of Kishigami and to further modify with the PC substrate of Chen. Final Office action of March 2, 2011, pp. 7-8.

Applicants respectfully traverse the rejections for the reasons set forth below.

The Applicants disclose a device in which electrons are transported by a conduction or hopping mechanism, and thus the thickness of the inorganic electron transport layer is desirably 100 nm or less. Specification, p. 4, line 29.

Amended independent claim 1, recites, *inter alia*:

a top electrode;

a bottom electrode disposed substantially opposite the top electrode and on a substrate including a polyethyleneterephthalate or a polycarbonate substrate;
an inorganic quantum dot light-emitting layer provided between the top electrode and the bottom electrode; and
an inorganic electron transport layer disposed between the inorganic quantum dot light-emitting layer and the top electrode, and
wherein a thickness of the inorganic electron transport layer is in a range of about 10 nanometers to about 100 nanometers.

Similarly, amended independent claim 10 recites:

a top electrode;
a bottom electrode disposed substantially opposite the top electrode and on a substrate including a polyethyleneterephthalate or a polycarbonate substrate;
an inorganic quantum dot light-emitting layer provided between the top electrode and the bottom electrode; and
an inorganic electron transport layer disposed between the inorganic quantum dot light-emitting layer and the top electrode,
wherein the inorganic electron transport layer includes an oxide selected from the group consisting of TiO_2 , ZnO , SiO_2 , SnO_2 , WO_3 , Ta_2O_3 , BaTiO_3 , BaZrO_3 , ZrO_2 , HfO_2 , Al_2O_3 , Y_2O_3 and ZrSiO_4 ; the nitride Si_3N_4 ; or a semiconductor compound selected from the group consisting of CdS , ZnSe and ZnS , and
wherein a thickness of the inorganic electron transport layer is in a range of about 10 nanometers to about 100 nanometers.

Bulovic is directed towards a light-emitting device including semiconductor nanocrystals, the device including a substrate 1 (Glass in FIG. 2), a first electrode 2 (ITO in FIG. 2), a first layer 3 (a hole transporting layer TPD:QDs in FIG. 2), an organic light-emitting layer of Alq3 (shown only in FIG. 2, but discussed as being between layers 3 and 4 with respect to an alternative embodiment of FIG. 1), a second layer 4, and a second electrode 5 (Mg:Ag and Ag in FIG. 2). (See FIGS. 1-2B and the associated description thereof in the specification of Bulovic).

Jain teaches light emission from the quantum dot core either by injection or by avalanche electroluminescence. Jain teaches in Fig. 6 an avalanche, non epitaxial device comprising a pseudomorphically cladded quantum dot nanocrystals sandwiched on dielectric layers. Jain, Abstract. Jain, col. 2, line 67. Jain teaches that in the case of Avalanche operation, the layer forming a reverse barrier junction should be thick enough to produce impact ionization that leads to avalanche multiplication of carriers. Jain, col. 4, lines 53-57. Accordingly, Jain teaches that “[r]elatively thick MQD structures are suitable for avalanche type EL devices” Jain, col. 4, lines 63-64. Thus one of ordinary skill in the art would understand that for operation of at least the avalanche device, the thickness of the dielectric layer should be several hundred nanometers to several micrometers.

Kishigami discloses an organic electroluminescent element including a cathode 2, an electron transport layer 3, an organic electroluminescent layer 4, a hole transport layer 5, an anode 6, and a substrate 7. See Abstract, associated figure and Title of the invention. The substrate of Kishigami uses a glass or metal.

Chen discloses a full color display panel with a mirror function comprising an organic light-emitting area 11 comprising a first electrode 111, an organic functional layer 112, and a second electrode 113. Chen, Fig. 2 and p. 2, [0025]. Chen also discloses that the organic light-emitting area 11 is on insulating layer 17, which is on spectrum modulation layer 12, and on a color separating layer 13, which in turn is on color filters 132, which are on a transparent substrate 14. Chen, p. 3, [0037]. Chen teaches that the insulating layer 17 “can be made of an organic compound or inorganic compound.” The Examiner alleges that transparent substrate 14 corresponds to the instantly claimed substrate. Office action of March 2, 2011, p. 3.

First, the combination of Bulovic, Jain, Kishigami, and Chen does not teach or suggest a quantum dot light-emitting diode wherein a thickness of the inorganic electron transport layer is in a range of about 10 nanometers to about 100 nanometers, as recited in independent claim 1 and in amended independent claim 10. As admitted by the Examiner, Bulovic does not disclose an inorganic electron transport layer, and thus does not teach or suggest a device wherein a thickness of the inorganic electron transport layer is in a range of about 10 nanometers to about 100 nanometers. Jain also does not teach a thickness of an inorganic electron transport layer. Jain teaches that “[r]elatively thick MQD structures are suitable for avalanche type EL devices... .” Jain, col. 4, lines 63-64. Chen, which discloses a full color display panel 1 comprising an

organic light emitting area 11, also does not teach or suggest a quantum dot light-emitting diode wherein a thickness of the inorganic electron transport layer is in a range of about 10 nanometers to about 100 nanometers, as recited in independent claim 1 and amended independent claim 10. Also, at least the English abstract of Kishigami, does not cure these deficiencies of Bulovic, Jain, and Chen. Thus the combination of Bulovic, Jain, Kishigami, and Chen would not have prompted an artisan to consider an inorganic electron transport layer having a thickness in a range of about 10 nanometers to 100 nanometers, as recited in independent claims 1 and 10. Also, at least the English abstract of Kishigami also does not teach or suggest an inorganic electron transport layer having a thickness of about 10 nanometers to about 100 nanometers, and thus Kishigami does not remedy this deficiency.

Thus, for at least these reasons, independent claims 1 and 10 are non-obvious over Bulovic, Jain, Kishigami, and Chen.

Second, the cited art does not teach or suggest a quantum dot light-emitting diode comprising, *inter alia*, a bottom electrode disposed substantially opposite the top electrode and on a substrate including a polyethyleneterephthalate or a polycarbonate substrate, as recited in independent Claims 1 and 10.

The Examiner admits that Bulovic and Jain are silent as to the substrate being made of polyethyleneterephthalate or a polycarbonate. Office action of March 2, 2011, p. 3. Bulovic discloses glass, for example. Bulovic, FIG. 2. Jain teaches a substrate made of sapphire or silicone and a thick semiconductor layer.

Kishigami discloses an organic electroluminescent element including a cathode 2, an electron transport layer 3, an organic electroluminescent layer 4, a hole transport layer 5, an anode 6, and a substrate 7. See Abstract, associated figure and Title of the invention. Regarding the substrate, Kishigami teaches a glass or metal, and thus a flexible device cannot be implemented by Kishigami, contrary to the claimed invention. Therefore, even if the electron transport layer of Bulovic were replaced with the inorganic electron transport layer of Kishigami for the purpose of enhancing the electron injection to the light emitting device and to improve the luminance efficiency of the device, as asserted in the instant Office action, the combined structure would not teach a bottom electrode disposed substantially opposite a top electrode and on a substrate including a polyethyleneterephthalate or a polycarbonate substrate, an inorganic

quantum dot light-emitting layer provided between the top electrode and the bottom electrode, and an inorganic electron transport layer disposed between the inorganic quantum dot light-emitting layer and the top electrode, as recited in independent Claims 1 and 10.

Chen teaches that the insulating layer 17 “can be made of an organic compound or inorganic compound” and thus would not have prompted an artisan to consider the desirability any particular material, let alone a polyethyleneterephthalate or a polycarbonate substrate, as recited in independent claims 1 and 10.

Thus because the prior art does not suggest the desirability of the modification suggested by the Examiner, one of ordinary skill in the art would not have been prompted to modify Bulovic, Jain, Chen, and Kishigami as suggested by the Examiner, let alone have an expectation of success. “Although the Commissioner suggests that [the structure in the primary art reference] could readily be modified to form the [claimed] structure, ‘[t]he mere fact that the prior art could be so modified would not have made the modification obvious unless the prior art suggested the desirability of the modification’”) (citation omitted) *In re Laskowski*, 871 F.2d 115, 117, 10 U.S.P.Q.2d 1397, 1398 (Fed. Cir. 1989); also obviousness cannot be established “by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion that the combination be made”. *In re Stencel*, 828 F.2d 751, 755, 4 U.S.P.Q.2d 1071, 1073 (Fed. Cir. 1987).

Thus because Chen teaches that the organic light emitting layer 11 comprises a first electrode 111, a hole injection layer 112, and a second electrode 113, and because Chen teaches that the organic light emitting layer 11 is directly on the insulating layer 17, and because Chen teaches that the insulating layer 17 can be essentially any material, the Applicants respectfully assert that in view of Chen an artisan would not have been prompted to have modified any combination of Bulovic, Jain, and Kishigami and have selected a polyethyleneterephthalate or a polycarbonate substrate, let alone have an expectation of success.

Second, because Chen teaches a full color display panel in which a spectrum modulation layer and a color separating layer are interposed between an organic light-emitting area 11 and the substrate 14, and thus teaches a device which is distinct from that of Bulovic and Jain, one of ordinary skill in the art would not have been prompted to modify Bulovic and Jain as suggested by the Examiner, let alone have an expectation of success.

Third, because Bulovic teaches a glass substrate, and because Jain teaches sapphire or silicone, one of ordinary skill in the art would not have been prompted to dispense with the materials disclosed in Bulovic and Jain and use the polycarbonate of Chen as suggested by the Examiner, absent some prompting in the cited art to engage in the suggested additional complexity and make the suggested modification.

Also, even if a *prima facie* case of obviousness were conceded, which it is not, it is respectfully submitted that applicant's invention is not obvious because the particular combination of claimed elements results in unexpectedly beneficial properties. An applicant can rebut a *prima facie* case of obviousness by presenting comparative test data showing that the claimed invention possesses unexpectedly improved properties or properties that the prior art does not have. *In re Dillon*, 919 F.2d 688, 692-93, 16 U.S.P.Q.2d 1987, 1901 (Fed. Cir. 1990).

The Applicants disclose in FIGS. 4-7 the results of evaluation of the device of Example 2. As shown in these figures, the device provides a variety of desirable properties, including improved intensity. For example, disclosed in FIG. 6 is emission of 199 Cd/m² at 16V, and about 0.08 Cd/A as shown in FIG. 7. The Applicants respectfully assert that these results further illustrate the non-obviousness of the instant claims.

Thus Bulovic, Jain, Chen, and Kishigami do not teach or suggest a quantum dot light emitting diode comprising a top electrode; a bottom electrode disposed substantially opposite the top electrode and on a substrate including a polyethyleneterephthalate or a polycarbonate substrate; an inorganic quantum dot light-emitting layer provided between the top electrode and the bottom electrode; and an inorganic electron transport layer disposed between the inorganic quantum dot light-emitting layer and the top electrode, wherein the thickness of the inorganic electron transport layer is in the range of about 10 nanometers to about 100 nanometers, as recited in amended independent claim 1.

Also, Bulovic, Jain, Chen and Kishigami do not teach or suggest a quantum dot light emitting diode comprising, *inter alia*, a substrate including a polyethyleneterephthalate or a polycarbonate substrate, as recited in independent claims 1 and 10.

Therefore, since Bulovic, Jain, Chen and Kishigami, alone or in combination, *fail to teach or suggest* all of the limitations of at least amended independent Claims 1 and 10, *prima facie* obviousness does not exist regarding amended independent Claims 1 and 10 with respect to

Bulovic, Jain, Chen, and Kishigami. Applicants respectfully submit that Claims 1 and 10 are not further rejected or objected and are therefore allowable to Applicants. As Claims 2-5 and 7-9 variously depend from Claim 1, they are correspondingly allowable. Entry of the claim amendments, reconsideration, withdrawal of the claim rejections under 35 U.S.C. § 103 and allowance of Claims 1-5 and 7-10 are respectfully requested.

Conclusion

In view of the foregoing, it is respectfully submitted that the instant application is in condition for allowance. Accordingly, it is respectfully requested that this application be allowed and a Notice of Allowance issued. If the Examiner believes that a telephone conference with Applicants' attorneys would be advantageous to the disposition of this case, the Examiner is cordially requested to telephone the undersigned.

Applicants hereby petition for any necessary extension of time required under 37 C.F.R. 1.136(a) or 1.136(b) which may be required for entry and consideration of the present Reply.

In the event the Commissioner of Patents and Trademarks deems additional fees to be due in connection with this application, Applicants' attorney hereby authorizes that such fee be charged to Deposit Account No. 06-1130.

Respectfully submitted,

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